

Contents

1	Introduction	1
1.1	Nonlinear Symmetric Dual Pair of Programming Problems	3
1.2	Motivation	4
2	Generalized Convex Functions	7
2.1	Convex and Generalized Convex Functions	8
2.2	Invex and Generalized Invex Functions	10
2.3	Type I and Related Functions	12
2.4	Univex and Related Functions	16
2.5	V -Invex and Related Functions	18
2.6	Further Generalized Convex Functions	22
3	Generalized Type I and Related Functions	25
3.1	Generalized Type I Univex Functions	25
3.2	Nondifferentiable d -Type I and Related Functions	27
3.3	Continuous-Time Analogue of Generalized Type I Functions	28
3.4	Nondifferentiable Continuous-Time Analogue of Generalized Type I Functions	31
3.5	Generalized Convex Functions in Complex Spaces	32
3.6	Semilocally Connected Type I Functions	33
3.7	$(\mathfrak{F}, \rho, \sigma, \theta)$ - V -Type-I and Related n -Set Functions	36
3.8	Nondifferentiable d - V -Type-I and Related Functions	38
3.9	Nonsmooth Invex and Related Functions	40
3.10	Type I and Related Functions in Banach Spaces	41
4	Optimality Conditions	45
4.1	Optimality Conditions for Vector Optimization Problems	45
4.2	Optimality Conditions for Nondifferentiable Vector Optimization Problems	48
4.3	Optimality Conditions for Minimax Fractional Programs	51

4.4	Optimality Conditions for Vector Optimization Problems on Banach Spaces	56
4.5	Optimality Conditions for Complex Minimax Programs on Complex Spaces	58
4.6	Optimality Conditions for Continuous-Time Optimization Problems	60
4.7	Optimality Conditions for Nondifferentiable Continuous-Time Optimization Problems	67
4.8	Optimality Conditions for Fractional Optimization Problems with Semilocally Type I Pre-invex Functions	73
4.9	Optimality Conditions for Vector Fractional Subset Optimization Problems	80
5	Duality Theory	91
5.1	Mond–Weir Type Duality for Vector Optimization Problems	91
5.2	General Mond–Weir Type Duality for Vector Optimization Problems	94
5.3	Mond–Weir Duality for Nondifferentiable Vector Optimization Problems	96
5.4	General Mond–Weir Duality for Nondifferentiable Vector Optimization Problems	99
5.5	Mond–Weir Duality for Nondifferentiable Vector Optimization Problems with d –Univex Functions	101
5.6	General Mond–Weir Duality for Nondifferentiable Vector Optimization Problems with d –Univex Functions	105
5.7	Mond–Weir Duality for Nondifferentiable Vector Optimization Problems with d –Type-I Univex Functions	107
5.8	General Mond–Weir Duality for Nondifferentiable Vector Optimization Problems with d –Type-I Univex Functions	111
5.9	First Duality Model for Fractional Minimax Programs	114
5.10	Second Duality Model for Fractional Minimax Programs	117
5.11	Third Duality Model for Fractional Minimax Programs	119
5.12	Mond–Weir Duality for Nondifferentiable Vector Optimization Problems	121
5.13	Duality for Vector Optimization Problems on Banach Spaces	126
5.14	First Dual Model for Complex Minimax Programs	128
5.15	Second Dual Model for Complex Minimax Programs	132
5.16	Mond–Weir Duality for Continuous–Time Vector Optimization Problems	135
5.17	General Mond–Weir Duality for Continuous–Time Vector Optimization Problems	138
5.18	Duality for Nondifferentiable Continuous–Time Optimization Problems	141
5.19	Duality for Vector Control Problems	144
5.20	Duality for Vector Fractional Subset Optimization Problems	152

6	Second and Higher Order Duality	165
6.1	Second Order Duality for Nonlinear Optimization Problems	165
6.2	Second Order Duality for Minimax Programs	169
6.3	Second Order Duality for Nondifferentiable Minimax Programs	176
6.4	Higher Order Duality for Nonlinear Optimization Problems	181
6.5	Mond–Weir Higher Order Duality for Nonlinear Optimization Problems	184
6.6	General Mond–Weir Higher Order Duality for Nonlinear Optimization Problems	188
6.7	Mangasarian Type Higher Order Duality for Nondifferentiable Optimization Problems	189
6.8	Mond–Weir Type Higher Order Duality for Nondifferentiable Optimization Problems	193
6.9	General Mond–Weir Type Higher Order Duality for Nondifferentiable Optimization Problems	195
7	Symmetric Duality	199
7.1	Higher Order Symmetric Duality	199
7.2	Mond–Weir Type Higher Order Symmetric Duality	203
7.3	Self Duality	209
7.4	Higher Order Vector Nondifferentiable Symmetric Duality	210
7.5	Minimax Mixed Integer Optimization Problems	214
7.6	Mixed Symmetric Duality in Nondifferentiable Vector Optimization Problems	215
7.7	Mond–Weir Type Mixed Symmetric First and Second Order Duality in Nondifferentiable Optimization Problems	224
7.8	Second Order Mixed Symmetric Duality in Nondifferentiable Vector Optimization Problems	232
7.9	Symmetric Duality for a Class of Nondifferentiable Vector Fractional Variational problems	241
8	Vector Variational-like Inequality Problems	255
8.1	Relationships Between Vector Variational-Like Inequalities and Vector Optimization Problems	255
8.2	On Relationships Between Vector Variational Inequalities and Vector Optimization Problems with Pseudo-Univexity	260
8.3	Relationship Between Vector Variational-Like Inequalities and Nondifferentiable Vector Optimization Problems	264
8.4	Characterization of Generalized Univex functions	269
8.5	Characterization of Nondifferentiable Generalized Invex Functions	275
	References	281
	Index	293